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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/712,945	11/13/2003	Jae Suk Lee	20059/PIA30962	9550
34431	7590	05/25/2006	EXAMINER	
HANLEY, FLIGHT & ZIMMERMAN, LLC			ARENA, ANDREW OWENS	
20 N. WACKER DRIVE			ART UNIT	
SUITE 4220			PAPER NUMBER	
CHICAGO, IL 60606			2811	

DATE MAILED: 05/25/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

**Advisory Action
Before the Filing of an Appeal Brief**

Application No.

10/712,945

Applicant(s)

LEE, JAE SUK

Examiner

Andrew O. Arena

Art Unit

2811

--The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

THE REPLY FILED 10 May 2006 FAILS TO PLACE THIS APPLICATION IN CONDITION FOR ALLOWANCE.

1. ☒ The reply was filed after a final rejection, but prior to or on the same day as filing a Notice of Appeal. To avoid abandonment of this application, applicant must timely file one of the following replies: (1) an amendment, affidavit, or other evidence, which places the application in condition for allowance; (2) a Notice of Appeal (with appeal fee) in compliance with 37 CFR 41.31; or (3) a Request for Continued Examination (RCE) in compliance with 37 CFR 1.114. The reply must be filed within one of the following time periods:

- a) ☒ The period for reply expires 4 months from the mailing date of the final rejection.
b) ☐ The period for reply expires on: (1) the mailing date of this Advisory Action, or (2) the date set forth in the final rejection, whichever is later. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of the final rejection.

Examiner Note: If box 1 is checked, check either box (a) or (b). ONLY CHECK BOX (b) WHEN THE FIRST REPLY WAS FILED WITHIN TWO MONTHS OF THE FINAL REJECTION. See MPEP 706.07(f).

Extensions of time may be obtained under 37 CFR 1.136(a). The date on which the petition under 37 CFR 1.136(a) and the appropriate extension fee have been filed is the date for purposes of determining the period of extension and the corresponding amount of the fee. The appropriate extension fee under 37 CFR 1.17(a) is calculated from: (1) the expiration date of the shortened statutory period for reply originally set in the final Office action; or (2) as set forth in (b) above, if checked. Any reply received by the Office later than three months after the mailing date of the final rejection, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

NOTICE OF APPEAL

2. ☐ The Notice of Appeal was filed on _____. A brief in compliance with 37 CFR 41.37 must be filed within two months of the date of filing the Notice of Appeal (37 CFR 41.37(a)), or any extension thereof (37 CFR 41.37(e)), to avoid dismissal of the appeal. Since a Notice of Appeal has been filed, any reply must be filed within the time period set forth in 37 CFR 41.37(a).

AMENDMENTS

3. ☐ The proposed amendment(s) filed after a final rejection, but prior to the date of filing a brief, will not be entered because
(a) ☐ They raise new issues that would require further consideration and/or search (see NOTE below);
(b) ☐ They raise the issue of new matter (see NOTE below);
(c) ☐ They are not deemed to place the application in better form for appeal by materially reducing or simplifying the issues for appeal; and/or
(d) ☐ They present additional claims without canceling a corresponding number of finally rejected claims.

NOTE: _____. (See 37 CFR 1.116 and 41.33(a)).

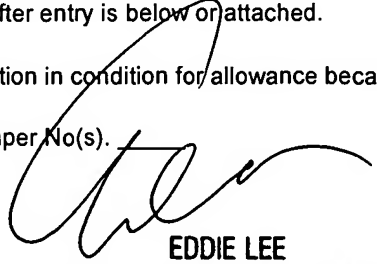
4. ☐ The amendments are not in compliance with 37 CFR 1.121. See attached Notice of Non-Compliant Amendment (PTOL-324).
5. ☒ Applicant's reply has overcome the following rejection(s): all rejections under 35 U.S.C. 112, first paragraph.
6. ☐ Newly proposed or amended claim(s) _____ would be allowable if submitted in a separate, timely filed amendment canceling the non-allowable claim(s).
7. ☒ For purposes of appeal, the proposed amendment(s): a) ☐ will not be entered, or b) ☒ will be entered and an explanation of how the new or amended claims would be rejected is provided below or appended.
The status of the claim(s) is (or will be) as follows:
Claim(s) allowed: n/a.
Claim(s) objected to: n/a.
Claim(s) rejected: 12-20.
Claim(s) withdrawn from consideration: n/a.

AFFIDAVIT OR OTHER EVIDENCE

8. ☐ The affidavit or other evidence filed after a final action, but before or on the date of filing a Notice of Appeal will not be entered because applicant failed to provide a showing of good and sufficient reasons why the affidavit or other evidence is necessary and was not earlier presented. See 37 CFR 1.116(e).
9. ☐ The affidavit or other evidence filed after the date of filing a Notice of Appeal, but prior to the date of filing a brief, will not be entered because the affidavit or other evidence failed to overcome all rejections under appeal and/or appellant fails to provide a showing of good and sufficient reasons why it is necessary and was not earlier presented. See 37 CFR 41.33(d)(1).
10. ☐ The affidavit or other evidence is entered. An explanation of the status of the claims after entry is below or attached.

REQUEST FOR RECONSIDERATION/OTHER

11. ☒ The request for reconsideration has been considered but does NOT place the application in condition for allowance because:
See Continuation Sheet.
12. ☐ Note the attached Information Disclosure Statement(s). (PTO/SB/08 or PTO-1449) Paper No(s).
13. ☐ Other: _____.


EDDIE LEE
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 2800

Continuation of 11. does NOT place the application in condition for allowance because:

Applicant's arguments filed 05/10/2006 have been fully considered but they are not persuasive.

Applicant's arguments that "Anand does not further teach the selection of particular materials for either the first or second conductive layers" and that "Anand does not affirmatively disclose an embodiment where the first and second metal lines are formed of different materials" are not persuasive. Anand discloses the first conductive layer is formed of a material (aluminum copper alloy; col 7 ln 66-67) different from a material of the second conductive layer (copper; col 8 ln 66-67), therefore Anand does enable "a structure where the first metal lines prevent ions of the second metal lines from being diffused into the substrate." The fact that Anand allows for other possible structures ("Thus, both the first and second conductive layers of Anand may comprise the same material") does not negate the fact that Anand anticipates applicant's claimed structure.

Applicant's arguments with respect to the combinations of Anand with Xu and Anand with reference "U" are not persuasive. Insofar as Anand does indeed disclose "a stacked hybrid structure wherein a first conductive layer is formed of a material different from that of a second conductive layer such that the first metal lines prevent ions of the second metal lines from being diffused into the substrate", any combination of Anand also discloses said feature.

Regarding applicant's statement that reference "U" was "not provided to the applicant by the examiner or available to applicant's representative at the location cited by the examiner", another copy of reference "U" is included with this advisory action. Examiner notes that in not raising the issue of the allegedly missing reference until the after-final amendment dated 10 May 2006, the applicant did not contact the examiner in a timely manner, accordingly, the statutory period for response will not be reset or extended.

SESSION N5: FLUORINATED OXIDES AND POLYIMIDES

Chair: Neil H. Hendricks

Friday Morning, April 4, 1997

Golden Gate B3

8:30 AM *N5.1

LOW-DIELECTRIC CONSTANT FLUORINE-DOPED TEOS FILMS, Viren V.S. Rana, Applied Materials Inc, Dielectric CVD Div I, Santa Clara, CA; Anand Gupta, Applied Materials Inc, DVCDI, Santa Clara, CA; Soonil Hong, David Cheung, Peter Lee, Applied Materials Inc, Dielectric CVD Div I, Santa Clara, CA.

Fluorine doping of TEOS films (FTEOS) has been of considerable interest since the fluorine doping has been known to reduce the dielectric constant and also improve the step coverage. Dielectric films with a lower dielectric constant (k) than the current SiO_2 ($k = 4.0-4.2$) are required at feature sizes below $0.5 \mu\text{m}$ to reduce the interconnect RC delays. Also, the improved step coverage can help as the intrametal gap aspect ratios increase with decreasing feature size. For application in sub-half-micron ULSI devices, the FTEOS films besides having a low dielectric constant need to be stable to a high temperature ($> 500^\circ\text{C}$) and have chemical and electrical compatibility with devices. Precursors such as C_2F_6 , FTES, and SiF_4 have been used to obtain low dielectric constant FTEOS films. For similar fluorine concentrations the film stability and the step coverage is different for different dopant precursor. At high $[\text{F}]$ concentrations films become thermally unstable leading to fluorine evolution. The fluorine stability is related to the presence of SiF_2 bonds. The films can be made stable by changing the process conditions that increase the decomposition of TEOS and the precursor, and densify the film. It is easiest to make the SiF_4 based films stable. Stable films with a dielectric constant of 3.5, containing about 7 atomic% fluorine have been obtained. This appears to be the limit of $[\text{F}]$ doping while maintaining the film stability. There appears to be a tradeoff between step coverage and film stability. As the films are made stable the step coverage degrades. A choice between low dielectric constant and enhanced gap fill may need to be made. These applications will be highlighted.

9:00 AM N5.2

NOVEL APPROACHES TO LINEAR POLYIMIDES, J. P. Marasco, J. Garapon, Bernard D. Sillion, CNRS, Lab des Matls Organiques a Prop Specif, Vernaison, FRANCE.

The mechanical and dielectric properties of the thin coating of polyimides made these polymers very important for application, as permanent dielectrics in the manufacture of integrated circuits (IC) and multichip modulus (MCM). From the IC and MCM manufacturer point of view, the polyamic acid intermediates is an important drawback and many pathways have been explored to produce polyimide through more stable intermediates. In this paper, we discuss two new approaches based on the polyimide orthoamide chemistry:

- 1) the bis-isoimides react with aromatic diamine. A model compound study shows that the rate of isoimide reaction with an amine is correlated to the Hammett coefficient of the p-substituent carried by Ar^1 . A nitrogroup gives the highest rate for the preparation of the amide and the highest selectivity (100 %) during the cyclization catalyzed by the bases. The hydrolytic stability of the Intermediate polyamide o-amide is excellent.
- 2) the second way is based on the chemistry of bis-secondary amide bisimidazolide; the p-isomer can be obtained with high purity and allows the formation of soluble rod-like stable intermediates which behave as stable lyotropic solutions.

9:15 AM N5.3

CHARACTERIZATION OF PHOTSENSITIVE AND SELF-ADHESIVE POLYIMIDE, Terry L. Alford, Y. Lee Zou, James W. Mayer, Arizona State Univ, Dept of Chem Biochem & Matls Engr, Tempe, AZ.

A modified ODPA/DDBP polyimide is definable in i-line stepper, and it does not require an external adhesion promoter. Since physical and properties are essential for resolution in photolithography, as well as for adhesion of polyimide to the substrate, various techniques were used to characterize the polymeric material. Thermal

mechanical analysis (TMA) has shown a low coefficient of thermal expansion (20 ppm/°C) and a high glass transition temperature (320°C). The thermal stability was further evaluated by measuring reproducibility of a pattern and film thickness change before and after the curing. The surface chemistry was studied using a time-of-flight secondary ion mass spectrometry (TOF-SIMS), which identified adhesion promoting functional groups. Contact angles of three liquids on polyimide film were measured by dynamic contact angle analyzer (DCA). The surface energies were derived based on the contact angles and were correlated to the degree of imidization.

9:30 AM N5.4

THERMAL STABILITY STUDY OF THE INTERCONNECT SYSTEM WITH FLUORINATED SILICATE GLASS AS IMD LAYERS, Weidan Li, Wilbur Catabay, LSI Logic, R&D Div, Santa Clara, CA .

Fluorinated silicate glass (FSG) has been studied as a low k intermetal dielectric (IMD) material in the multilevel interconnect systems. In such a system, FSG is usually combined with undoped oxide or polymer materials to form IMD layers. The thermal stability of the FSG film will have significant impact on the device reliability. In this study, the thermal stability of different types of PE-CVD FSG films was evaluated with TDS, SIMS, and SEM analysis. The TDS data were compared with the F diffusion data. It was observed that F is easier to diffuse into an undoped film than to be desorbed at elevated temperatures. The data indicate that F diffuses 3.5 times faster in a silicon oxide film than in a silicon nitride film. The FSG films were applied to a sub-half-micron VLSI as the IMD layers. The devices were tested using an intensive thermal stability testing methodology in which wafers were heated up to 420°C for 30 min and then cooled down to room temperature. The thermal cycle was repeated seven times. Electric data did not show significant drift after the thermal cycles. However, failure analysis indicated that in some splits, TiSi_2 reacted with F diffused from the FSG film. The reaction caused TiSi_2 delamination. It was also observed that diffused F also reacted with Ti, resulting in metal blistering. All these reactions will cause device reliability degradation. Barriers were studied to solve the problem. With an optimized process and interconnect structure, the problem was eliminated as demonstrated using the intensive thermal stability test.

10:15 AM N5.5

THERMAL STRESSES, INTERFACIAL REACTIONS AND MICROSTRUCTURES OF Al/Ti AND Al/TiN THIN FILMS ENCAPSULATED BY FLUORINATED SILICON DIOXIDES, Wei-Tsu Tseng, National Chiao Tung Univ, National Nanl Device Laboratories, Hsinchu, TAIWAN; Li-Wen Chen, G.-C. Tu, Chiao-Tung Univ, Inst of MS&E, Hsinchu, TAIWAN.

The incorporation of low-dielectric-constant (low-k) fluorinated silicon dioxide (SiOF) into the multilevel interconnect structures poses potential reliability concerns due to the existence of fluorine. While SiOF may help mitigate the thermally-induced tensile stress in metallizations, the out diffusion of fluorine into metallization layers during thermal cycles would lead to increase in electrical resistance and deterioration of metallizations. In this study, thermal stresses and microstructures of Al alloy thin films encapsulated by SiOF with varying fluorine concentrations are investigated. Barrier layers such as Ti and TiN are inserted between SiOF and Al layers and their blocking capability against fluorine diffusion is examined. Preliminary results suggest that the penetration of fluorine alters the Al microstructures significantly. In addition, mechanical characteristics of the overlying dielectric layers are found to affect the stresses and microstructures of Al notably. The formation of Al-Ti intermetallics during thermal cycles and its impacts on stresses, microstructures and fluorine contamination in Al layers are also investigated. Finally, the correlations between stresses, microstructures and fluorine contamination and their significance in the designs of metallizations for reliability will be discussed.

10:30 AM N5.6

MICROSCOPIC MECHANISMS FOR REDUCED STATIC DIELECTRIC CONSTANTS IN SI-O-F FILMS, Hong Yang, North Carolina State Univ, Dept of Chemistry, Raleigh, NC; Gerald Lucovsky, North Carolina State Univ, Dept of Physics, Raleigh, NC.

There is considerable interest in insulating films with static dielectric constants lower than that of SiO_2 . One

alloy system that has attracted recent attention is Si-O-F. Incorporation of F atoms into SiO₂ leads to significant changes in the infrared (IR) absorption in the SiO₂ bond-stretching and bond-bending bands at 1060 cm⁻¹ and 800 cm⁻¹, respectively. An upward shift of the bond-stretching spectral peak indicates an upward shift in the distribution of Si-O-Si bond angles. The large changes in the static dielectric constants in Si-O-F films can not be explained by the replacement of Si-F for Si-O-Si groups. For the concentration ranges of technological interest to about 10 at. %, F atoms are incorporated into monohydride bo groups in which each Si-F is back-bonded to three Si-O-Si groups. IR experiments are interpreted by a model in which the vibrational absorptions of the back bonded Si-O-Si groups are reduced by inductive effects from the Si-F group. The mechanism of inductively reduced IR activity has been explored and verified by ab initio calculations. Calculations have been performed on molecular clusters to first obtain the harmonic force constants, k_i , and IR effective charges, e_i^* , for the three normal Si-O-Si modes as a function of the Si-O-Si bond angle, and then to determine changes induced by the F atom substitutions. The k_i and e_i^* of the bond-stretching and bond-bending modes of the Si-O-Si groups show complementary behaviors with respect to the dependence on the Si-O-Si bond angles. The large changes in the static dielectric constants of Si-O-F alloys are fully explained by a combination of i) replacement of weaker IR active Si-F bonds for stronger Si-O bonds, and ii) inductive effects of the Si-F group on the three back-bonded Si-O-Si groups which reduce their IR effective charges.

Supported by ONR and Intel Corporation

10:45 AM N5.7

THE EFFECT OF OH CONTENT ON THE DIELECTRIC CONSTANT OF FLUORO-SILICATE GLASS THIN FILMS, Mark T. Weise, Steve C. Selbrede, Mattson Technology, Fremont, CA.

In a work previously published by the authors¹, it was shown that OH incorporation was the dominant effect in unstable fluorinated silicon dioxide (FSG) films. This work will investigate the effect of OH incorporation on FSG dielectric constant. The data indicate that OH incorporation has a substantial, deleterious effect on the dielectric constant of FSG films. FSG films were deposited from a TEOS, O₂ and C₂F₆ mixture in a

commercially available PECVD reactor. The depositions were performed using dual RF frequency power at low pressure, 500-750 mTorr. The dielectric constant of the FSG films was investigated as a function of various film properties. The effects of gas flow ratios, refractive index, fluorine content, and OH content on dielectric constant were examined. The dielectric constant of the films was found to depend on both fluorine and OH content. Adding fluorine resulted in a lowered dielectric constant. Increasing OH content of FSG films raised the dielectric constant, which is consistent with previously reported results for undoped SiO₂ films. In some cases the increase in dielectric constant from OH can completely offset the dielectric constant reduction from fluorine incorporation. This observation has important ramifications in the handling of FSG films because FSG films have a tendency to absorb moisture upon exposure to room air.

¹M.T. Weise, S.C. Selbrede, L.J. Arias, D. Carl, Proceedings AVS Fall Symposium 1996.

11:00 AM N5.8

ADHESION STRENGTH AND DEFORMATION BEHAVIOR OF Al(Cu)/BPDA-PDA-LAYERED STRUCTURES, Peter P. Abramowitz, Ennis T. Ogawa, Univ of Texas-Austin, Austin, TX; Paul S. Ho, Univ of Texas-Austin, Dept of MS&E, Austin, TX; Jeffrey T. Wetzel, Motorola Inc, Mats Research & Strategic Technologies, Austin, TX.

As the dimensions of interconnects decrease it becomes more important to understand how the metal/polymer interface affects the deformation properties of the system. We have performed uniaxial strain tests on Al(Cu) lines with thickness between 0.2 and 1 μm on BPDA-PDA samples which have undergone various amount of RF-sputter pretreatment. We find that the adhesion energy of the Al(Cu) lures are greatly enhanced on any sample where the BPDA-PDA was RF-sputtered. However, the amount of sputtering had little effect on the adhesion strength. We also looked at the deformation of the metal lines with scanning probe microscopy (SPM) and found that plastic deformation develops in both sputtered and nonsputtered cases; however, more extensive deformation occurs in the sputtered cases, especially at strains larger than 15%. We then performed uniaxial

strain tests of blanket Al(Cu) lines on sputtered and nonsputtered BPDA-PDA so that the differences in deformation between these systems can be explored. We found that the energy needed to strain the sputtered BPDA-PDA case is significantly larger than the nonsputtered case. However, we have confirmed by experiment that this change of energy does not come from a hardening of the polymer by sputtering, nor by delamination. It most probably comes from a different amount of interaction between the polymer and metal. This effect cannot be modeled by continuum mechanics as the metal and polymer in both systems are identical, are being exposed to the same strain, and the interface retains its integrity. This highlights how the interaction between the metal and polymer can affect the deformation characteristics of both materials and how increased adhesion energies can lead to increased interaction between the layers.

11:15 AM N5.9

EFFECT OF POST PLASMA TREATMENT ON RELIABILITY AND DIELECTRIC PROPERTIES OF SiOF FILMS DEPOSITED BY ECRCVD WITH SiF₄ AND O₂, Seoghyeong Lee, Jae-Yoon Yoo, Jong-Wan Park, Hanyang Univ, Dept of Metall Engr, Seoul, SOUTH KOREA.

The effect of post plasma treatment on moisture absorption and dielectric properties of SiOF films was studied for application to intermetal dielectric (IMD) in multilevel metallization. SiOF films were deposited as a function of the SiF₄/O₂ gas flow ratio. Post plasma treatments of SiOF films were carried out in-situ after deposition using N₂, O₂, and N₂O gases. Changes in water absorption and dielectric properties of SiOF films were monitored as a function of exposure time in the atmosphere to learn the effect of the post plasma treatment. The wet etching rates were measured by dissolving films in a BOE (6:1) solution and FTIR spectra were examined in order to investigate differences in the chemical properties of SiOF films before and after the plasma treatments. XPS was also taken to investigate the effect of the plasma treatment on the surface chemical composition and depth profile of SiOF films. By FTIR analysis, after O₂ plasma treatment, no appreciable peak directly related to water absorbance was detected. It is regarded that the O₂ plasma treated SiOF film is more dense than nonplasma treated films because of ion bombardment effect of O₂ plasma. And it is also thought that some of F atoms in the very top layers of the SiOF film are replaced by oxygen atoms. In order to clarify the thermal stability of SiOF films as an IMD, the HTS test was carried out for various metallization systems such as Al (or Cu)/TiN/SiOF and Al(or Cu)/WN/SiOF. Furthermore, gap filling capability and step coverage are discussed in terms of cross sectional morphology of SiOF films deposited on patterned substrates under various deposition conditions.

11:30 AM N5.10

DIELECTRIC AND ELECTRICAL PROPERTIES OF LARC-Si: A SELF-BONDING POLYIMIDE MATERIAL, Xing-Zhong Zhao, Pennsylvania State Univ, University Park, PA; Joseph P. Dougherty, Sei-Joo Jang, L. Eric Cross, Pennsylvania State Univ, Ctr for Dielectric Studies, University Park, PA.

The self-bonding polyimide material called LARC-SI (Langley Research Center-Soluble Imide) developed by NASA is a promising candidate for producing adhesiveless, multilayer flexible circuits. Dielectric and electrical properties characterization is important to identify the most suitable application for this material. The relative dielectric constant and dielectric loss of this material have been measured over a temperature range of -60 to 250°C and a frequency range of 1 KHz to 2 MHz. The influence of sample thickness, heating and cooling cycle, glass transition of the material and environmental humidity on the dielectric properties are also studied. Temperature dependence of DC conductivity under various DC drive, temperature dependence of I-V characteristics, and time dependence of charging and recharging current measurement results are also presented to clarify the steady and transient current characteristics of this material. The application of this material to microelectronics is discussed.

11:45 AM N5.11

MATERIAL PROPERTIES AND PROCESS SEQUENCE INTEGRATION OF LOW-K HIGH-DENSITY PLASMA CVD FLUOROSILICATE GLASS FILMS FOR ADVANCED INTERMETAL DIELECTRIC APPLICATIONS, Maciek E. Orczyk, Laxman Muruges, Pravin Narwankar, Mihrimah Ozkan, Shijian Li,

Turgut Sahin, Farhad Moghadam, Applied Materials Inc, Santa Clara, CA.

Increased complexity of advanced IC devices is the driving force for progressing radical shrinkage of critical device dimensions, and also the main stimulus for the application of novel low-k IMD materials. Fluorosilicate glass (FSG) dielectric deposited using High Density Plasma (HDP) CVD technology is considered to be the main candidate for the near future device generations. In the case of undoped silica glass, HDP-CVD has already been proven from the point of view of robust film properties and very good intermetal gap-fill capabilities. In this communication we report on material characterization, process window description, and process sequence integration of low-k FSG films deposited using HDP-CVD technology. A brief overview of second-generation High Density Plasma CVD reactor type for low-k processing is presented. In the first part, the differences between HDP-FSG films deposited from different fluorine precursors are discussed. Also, the essential resulting there from conclusions regarding thermal and time stability of the dielectric are shared. In the second part, we focus on important physical parameters of the dielectric, and on their dependence on process conditions. Most important process window defining trends are discussed. Data regarding film's dielectric constant, refractive index, stress, FT-IR spectrum, uniformity of doping, and depth-profile atomic spectroscopy are demonstrated. We also present results of process integration of low-k HDP-FSG films with other VLSI/ULSI IC processing technologies. Results and recommendations regarding integration with dielectric etch, different advanced metallization schemes, and chemical-mechanical planarization will be shared and discussed.

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